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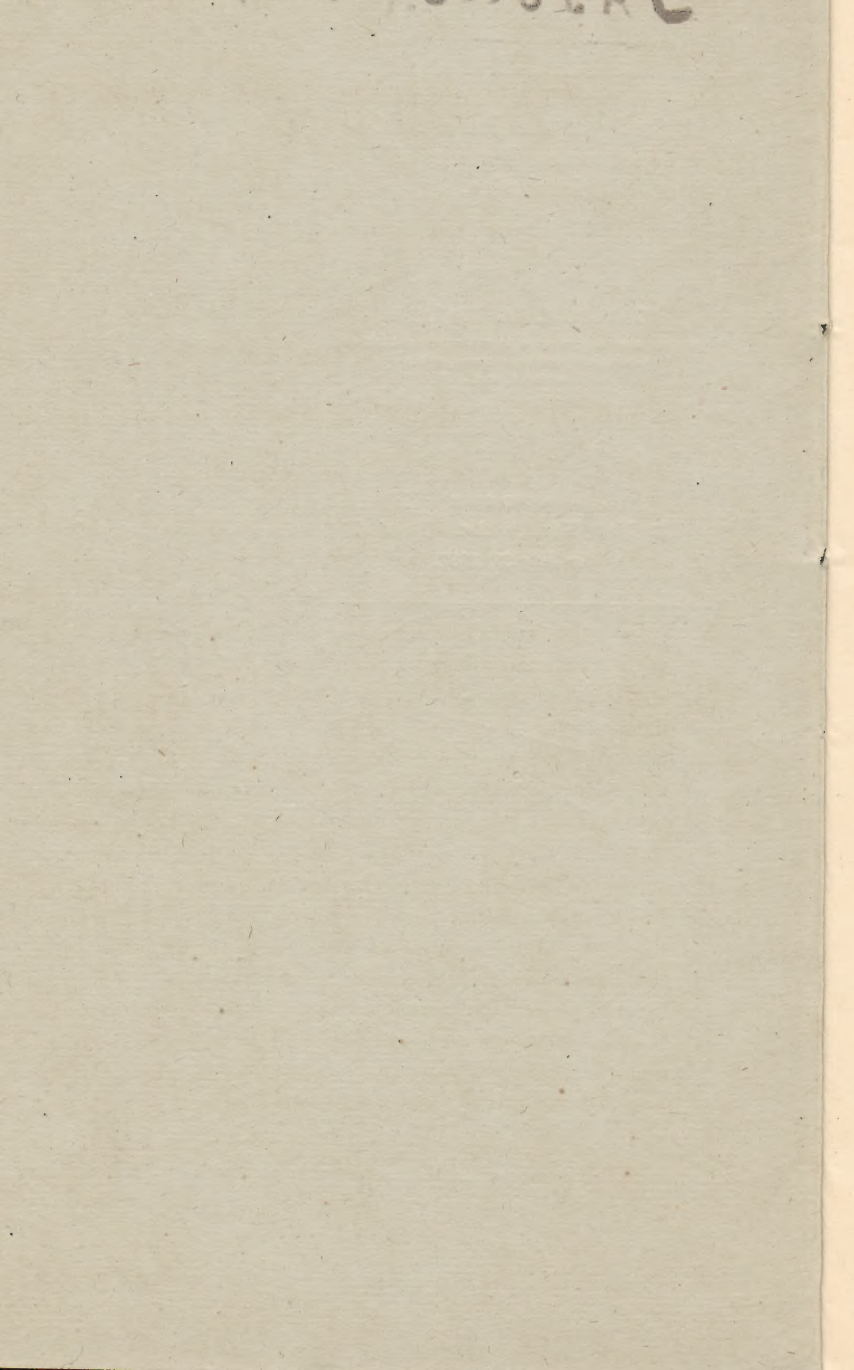
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A STUDY OF THE PRINCIPAL OBJECTIONABLE FEATURES OF INTUBATION.*

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As the literature of intubation increases, a firm believer in its many advantages can not but behold with regret the statistical evidence which, although numerically increasing daily, does not improve its relative position as regards its powerful opponent, tracheotomy. This is certainly a source of sorrow to the physician who has had repeatedly to witness the mental agony of fond parents, for he hailed intubation as at least a substitute to the ever-dreaded knife—a substitute entailing less physical suffering upon the patient, less mental suffering upon the relatives. These advantages not only implied greater liberty of action, but less hesitation, less delay, not uncommon causes of a fatal issue.

The proportion of recoveries after tracheotomy, according to Agnew, who based his calculations upon ten thousand cases, is about 30 per cent. In intubation, a list of three hundred and fifteen cases, computed by myself, showed that

* Read before the American Laryngological Association at its ninth annual congress.

only $25\frac{1}{10}$ per cent. were successful—a difference of $4\frac{9}{10}$ per cent. in favor of tracheotomy. It does not compete with the latter, therefore, but stands second to it, to be resorted to when the former is not permitted. This secondary position it has about held for the past year, and since, as time advances, there does not seem to be an increase in the proportionate number of recoveries, the profession is gradually becoming accustomed to intubation in the light of an easier, but less promising, operation than tracheotomy.

O'Dwyer's contribution to practical medicine is worthy of a higher standard. Its inherent qualities are too numerous not to raise it ultimately to the first rank. Had Bouchut been able to present even the bare 25 per cent. of recoveries, and "tubage" received since then the attention that tracheotomy has received, and consequently reached the perfection that the latter has, the question of comparison would not to-day present itself. Tracheotomy would not only be secondary to intubation in the sense here understood, but it would be limited entirely to different classes of cases. As it stands to-day, intubation is encumbered in its progress by not a few real defects. Analyzing these, and studying their cause, will, I am sure, lead to their early correction, and soon annul the dangers resulting from them. In presenting this paper I merely wish to record the result of a little thinking, and in doing so it is my humble desire merely to suggest a plan of action that will, in my opinion, soonest bring about the desired result. In this I feel that I am morally supported by Dr. O'Dwyer; and, if I differ with him in several emitted opinions and herein present them without reserve, he will, I hope, bear in mind that I am one of his warmest admirers.

I am confident of the ultimate success and of the greater ultimate comparative value of intubation over tracheotomy, because I am of the opinion that the difficulties militating

against the former are purely mechanical; while a close study of these mechanical defects has led me to believe that they are in turn due to erroneous conclusions as to the relative action of several prominent factors in the general plan of procedure.

Taking the principal objections to intubation, and arranging them according to the degree of danger attending them, we have:

1. Obstruction of the tube by fragments of membrane.
2. Crowding down of loose membrane during introduction of the tube.
3. Passage of food through the tube into the trachea, and consequent inability to feed sufficiently through the mouth.
4. Momentary arrest of respiration during introduction, and shock resulting therefrom.
5. Liability of the tube to be coughed out, and slipping of the tube into the trachea.

1. *Obstruction of the Tube by Fragments of Membrane.*
—This defect I believe to be due (1) to the limited diameter of the interior of the tube; (2) to its internal conformation.

As to the first defect, Dr. O'Dwyer considers a limited diameter of the tube necessary to preserve the expulsive force of cough in the expulsion of detached pseudo-membrane. To use his words: "Cough, to have its full expulsive power, requires a full inspiration, complete closure of the glottis, and then a violent expiratory effort, which compresses the air in the lungs, and forces it through the small space between the still contracted vocal cord. Coughing through a tube, on the contrary, whether in the larynx or trachea, means inability to close the glottis, with little power of compressing the air, and, consequently, little expulsive power. Therefore, the smaller the tube, compatible

with free respiration, the better, as there will be more power to expectorate, and less accumulation of secretions in the air-passages, which predisposes to the development of bronchial catarrh and broncho-pneumonia." I can not agree with him in this opinion. The tube hanging loosely in the cavity of the trachea, and the head only closing the laryngeal aperture by its weight, it seems to me that the smaller the interior of the tube, the smaller the tube proper, and the more chance for the expulsive air-current of the cough to force itself out *around* the tube, between tissues too much swollen to render respiration between them possible, but still not resisting enough not to separate under the pressure of the air-column. The force exerted upon the membrane choking the tube depends, therefore, upon the amount of resistance the tissues surrounding the tube present to the passage of the air-current; if that resistance is great, and the membrane not too tightly wedged in the cavity, the fragment will be coughed out; if the surrounding tissues and the impacted membrane present more resistance than the air-current is able to overcome, the tube will be coughed out, if the latter is held loosely; if, on the contrary, the tube is too tightly held to be coughed out, asphyxia ensues. Here a defect becomes a virtue, and I do not think that I am mistaken in saying that loose tubes have saved many lives.

Close apposition of the vocal bands is only necessary to the expulsion of very small masses. We all know the power of the voiceless "hem" to bring up even quite small quantities of mucus, and the violence with which this movement sometimes causes small particles of mucus to fly out through the mouth. In the execution of this movement the vocal bands remain quite a distance apart. Bouchut states that in one of his cases great cyanosis existed, and that this was relieved by the ejection of false membrane through his tube. In a second case, the introduction of

the tube was followed by the expulsion, at two different times, of *casts* of the primary bronchus. Bouchut's tubes were large. Have we not here practical evidence that a narrow aperture is *not* necessary for the proper expulsion of the pseudo-membrane?

For the proper expulsion of loose membrane from any part of the trachea, the power of the air-current must exert itself equally upon all parts of the cavity, in order that every part of it be impinged upon by the mechanical pressure that the air-current affords. In order to obtain the greatest advantage from this force, the upper opening of the trachea must approximate as much as possible its general diameter, including that of the portion immediately above the bifurcation. If the upper orifice is constricted, the expulsive force centers itself there, and exerts no influence upon the pseudo-membrane. At the same time, only a part of the air-current passes out, while a part recoils, to counteract, to a degree, the expulsive force. A natural indication resulting from this argument would be to use a laryngeal tube approaching as nearly as possible the diameter of the normal larynx. I can not agree, therefore, with Dr. O'Dwyer, who says: "The smaller the tube compatible with free respiration, the better, as there will be more power to expectorate and less accumulation in the air-passages, which predisposes to bronchial catarrh and broncho-pneumonia."

2. *Crowding down of Detached False Membrane during the Introduction of the Tube.*—This accident has occurred a sufficient number of times to render it worthy of a prominent position in the list of dangers accompanying the operation. I believe it to be due principally to the length of the tubes. "The object of having them so long," says Dr. O'Dwyer, "is to retain the pseudo-membrane *in situ* as it becomes detached from the tracheal walls until macera-

tion takes place." I am inclined to consider this as a dangerous measure; it seems to me contrary to all teachings to mechanically retain over their seat of formation masses of an infectious product that serves but to add to the general toxæmia, both through the blood and through the inspired air. As prompt a deliverance of all pseudomembrane as possible would seem to me more compatible with our efforts to prevent extension to the lungs proper.

This reason, therefore, does not appear to me to hold good in accounting for the inordinate length of the tubes. Their action in crowding down membrane needs no explanation. The deeper the instrument sinks, the more opportunity it has of meeting detached portions which, untouched, would have remained innocuous. This danger, therefore, is proportionate to the length of the tube employed.

3. *Passage of Food through the Tube into the Trachea.*

—In considering this drawback, an important question presents itself. Is there not, in the occasional passage of food into the trachea, a prolific cause of broncho-pneumonia, corresponding, at least, with the ætiological position of tracheotomy in relation to that complication? Waxham, of Chicago, one of intubation's warmest advocates, who has probably had more experience than any man living in the performance of that operation, stated at a meeting of the Chicago Medical Society, held on February 7th last, that, "besides the difficulty of swallowing, food and fluids ran into the bronchial tubes through the cannula, and that it was true that many patients died from broncho-pneumonia from this source,"* presenting at the same time an ingenious attachment of his invention to overcome the difficulty. Again, to quote his words: "He (the physician)

* "Jour. of the Am. Med. Assoc.," March 12, 1887, p. 291.

may tell the people to feed it bread and milk, or semi-solids, and, if he investigate the matter, he will find that they are giving it half a teaspoonful of milk with a little bread, *and the milk trickles into the trachea* and the bread is rejected. If they are told to make a custard, they make it so soft and fluid that *it will trickle into the trachea.*" * Imagine a custard and milk rolling down into the trachea! And still I have not the least doubt that Dr. Waxham was perfectly right.

In a list of seventeen observers, it is a rather obvious fact that those who report the greatest number of cases characterized by marked difficulty in swallowing, report at the same time the greatest number of deaths from bronchopneumonia. This may be a mere coincidence, but I am inclined to believe that it is not.

Fletcher Ingals, in the proceedings of March 7th of the Chicago Medical Society, stated that, in the cases in which he had introduced the tube for other physicians, "those that recovered, he had insisted that they should drink absolutely nothing." In the last case he insisted upon this so strongly that "he cautioned the parents that if they gave the child a teaspoonful of water they would kill it."

That impediment to proper deglutition is an important defect of the operation is demonstrated by the fact that fifteen of the seventeen writers above alluded to mention it in connection with their cases in a more or less emphatic manner.

Dr. O'Dwyer believes this defect to depend principally upon the state of the epiglottis, the mobility of which may be very much crippled by inflammatory thickening. I doubt whether this is the case, as the proportion of cases in which the epiglottis is involved in the inflammatory process sufficiently to paralyze its functions is not to be com-

* "Cincinnati Lancet-Clinic," March 26, 1887.

pared with the number of cases in which deglutition becomes difficult. Again, difficulty in swallowing is mentioned as occurring only *after* the introduction of the tube in all the cases reported, a fact demonstrating that the difficulty is due to the presence of the tube.

The prevailing opinion respecting the cause of this objectionable feature is that it is due to the impediment offered by the head of the tube to the free action of the epiglottis, by preventing its close apposition to the upper portion of the larynx. That this is but a small part of the faulty mechanism is shown by the following words of Dr. O'Dwyer: "The heads of my first tubes were made very small, to permit them to sink well down in the larynx, so that the epiglottis could perform its function more perfectly. . . . Notwithstanding that I have quadrupled their size, I *can see no difference in the ability to swallow fluids.*" There must, therefore, be another cause. That cause I am inclined to believe to be the weight of the tube. Elevation of the larynx during the act of deglutition is as important a feature of the proper execution of that act as the contraction of the constrictors. The muscles presiding over this elevation are not strong; their duty being a fixed one, their power is proportionate to the weight that they are calculated to lift. There is, perhaps, a certain amount of latent force in them, to serve in case of necessity, but that latent force can be at its best only during health, and the general stiffness that pervades the entire throat during severe local inflammatory infiltration can but counteract it, to say the least. If we add weight to the burden, the exact power necessary will either be present or absent, according to the inherent strength of the muscles and to the degree of their involvement in the inflammatory process. It must not be forgotten that in swallowing the larynx ascends more toward the epiglottis than the epiglottis descends to the

larynx. If, therefore, the ascent of the former is checked by only one sixteenth of an inch, there will be an aperture left quite sufficient to allow a considerable quantity of fluid to enter.

4. *Momentary Arrest of Respiration during the Introduction of the Tube.*—Dr. L. L. Palmer, of Toronto, in an interesting article on intubation,* relates a case in which the introduction of the tube was followed by an increase in the pulse-rate of from fifteen to twenty beats, which continued until death. He recommends a short first attempt, with special effort, to render it successful. He is inclined to consider momentary asphyxias as greatly aggravating causes, and is considering whether in his case these did not cause extension of the local manifestations.

Although seldom alluded to, this feature of the operation must certainly carry along with it a pernicious effect upon the already semi-asphyxiated patient. Needless to say that it is due to the presence of the obturator, which blocks up the cavity of the tube from the time the tip enters the larynx until it is well in place.

5. *Liability of the Tube to be Coughed Out.*—This occurs in almost every case, and is due, in my opinion, to the conformation of the tube, which exposes it to the action of the air-current during cough, and causes it to be influenced by it as if it were a foreign body.

The principal mechanical defect in this case is again the limited diameter of the interior of the tube, which is out of proportion to that of the column of air. The pressure is, therefore, exerted *around* the instrument with sudden violence, assisting the suddenly narrowed portion of the air-current which passes *through* the tube, in lifting it bodily.

6. *Slipping of the Tube into the Trachea.*—Slipping of the tube into the trachea during efforts at withdrawal is

* "Canadian Practitioner," January, 1887.

probably due to narrowness of the head, the descent being also assisted by the weight of the instrument. Independently of these mechanical features, however, the accident principally depends upon the selection of an instrument too small for the cavity that it is to occupy.

Recapitulating, we have then: Obstruction of the tube by detached membrane, due to the limited diameter of its interior.

Crowding down of loose membrane during the introduction of the tube, due to its inordinate length.

Passage of food through the tube into the trachea, due principally to its weight.

Momentary arrest of respiration during the introduction of the tube, due to the presence of the obturator.

Liability of the tube to be coughed out, due principally to the limited diameter of the interior.

Slipping of the tube into the trachea, due to its weight and to the conformation of its head.

We have now considered the principal defects of intubation, and I have given you what to me seemed to be their origin. I may be right, I may be wrong in my conclusions. I give them to you for what they are worth—food for thought. Let me say, however, as an encouragement, that by eliminating from the statistics in my possession the cases of death that I thought might have been avoided, had the instruments reached the degree of perfection that they will some day reach, the proportion of recoveries, instead of 25 per cent., became 43 per cent. This is, of course, a mere estimate, imbued with a certain amount of guessing, but I feel confident that the time is not far distant when this record, at least, will stand to the credit of intubation. Then, even more than now, will O'Dwyer's patience and perseverance be appreciated. How many thousands of lives will it have saved!

In conclusion, I will show you a set of instruments that I have had constructed in which I have tried to incorporate the qualities that an intubation set should possess in accordance with the ideas set forth above. Their value will depend, of course, upon the correctness of my views. In devising them I based myself upon the principle that the natural conformation of the larynx should as much as possible be followed, in order to preserve for the patient, to the greatest degree possible, the natural physiological functions of the surrounding parts. They are more calculated to supply the larynx with a metallic coating to preserve its perviousness than with a tube, properly speaking. To construct the throat-piece, I took a plaster cast of a larynx, and this, in turn, served to sink a die, which was used to transfer its shape to thin sheets of metal (due attention being paid to strength). Each side being taken separately, two plates were obtained which, united on the sides, formed an accurate mold of the internal aspect of the laryngeal cavity from the ary-epiglottic folds down to below the vocal bands. You will notice, however, that the lower portion of the instrument extends on an average one inch below the bands. The two side-pieces are united immediately above the middle, and in doing so the edges are bent so as to prevent close apposition of the joints to the parts adjoining them. In this manner neither the anterior commissure nor the inter-arytenoid space is touched by the instrument. The two pieces work freely around the pins holding them together, the upper portions becoming approximated when the lower separate, and *vice versa*. When the latter is the case, the instrument assumes the shape of a sharp V. When it is introduced into the larynx it assumes the shape of a capital A, with a funnel at the top. In this position the separated lower branches are in the trachea, the narrow portion of the funnel is at the vocal cords, and the edge of the broad por-

tion of the funnel is just below the ary-epiglottic folds, its shape being such as to avoid any interference with the epiglottis. The mold presented on each side, near the top, two rounded protuberances corresponding with the ventricles of the larynx. Reproduced in the instrument, these protuberances form a convenient supporting point, resting as they do on the vocal bands below and within the ventricles above, the edge of the ventricular band resting in turn in the recess formed by the protuberance and the lower portion of the funnel on each side. It is thus held securely, the vocal band preventing its descent and the ventricular band its ascent. The internal portions of the protuberances serve for the hooks of the forceps. The general appearance of the instrument is that of a bivalve speculum. Dr. O'Dwyer's first idea was to use such an instrument. After experimenting a few times with one, he abandoned it to resort to tubes. The defect was that the mucous membrane of the inter-arytenoid space and adjoining parts "pressed forward between the edges of the separated valves and the dyspnoea returned."* The mechanical error in this case was that the valves were united near the top, so that, when they were separated by the action of the spring, a gap occurred opposite the inter-arytenoid space and adjoining parts below, and also opposite the anterior commissure, thus enabling the swollen membrane to invaginate itself into the interior of the instrument. In the instrument now shown the point of union is nearly half an inch *below* the level of the vocal band, so that when the instrument is in position a complete tube is formed extending from the top of the inter-arytenoid space to almost half an inch below the vocal bands. Although not fitting tightly within the larynx, the adjustment is such that, like a well-fitting shoe, it can not produce irritation in any particular spot.

* Northrup, New York "Medical Record," Dec. 11, 1886.

Its movements are automatic, the vocal bands opening and closing the valves, according to the relative position they occupy with them. When they are introduced, closed below, and pushed downward, the moment the point of junction is reached, the valves open below and close above, forming the tube. When the instrument is withdrawn it remains closed above until the joint is reached, when it suddenly opens, the lower portions closing. This arrangement renders introduction and withdrawal exceedingly easy. This mechanical arrangement should obtain the following advantages :

1st. We have almost the same breathing space as in the normal larynx, thus preventing as much as possible obstruction by detached membrane.

2d. The comparative shortness of the instrument and the early separation of the lower portions of the valves reduce greatly the danger of crowding down loose pseudo-membrane.

3d. The light weight of the instrument and the shape of the head avoid interference with the act of deglutition.

4th. Separation of the valves a short distance above their tips, when closed, enables the patient to breathe freely while the instrument is being introduced.

5th. The fact that the force of the air-current is exerted in the center of the instrument and has sufficient space to pass freely, renders ejection during cough almost impossible.

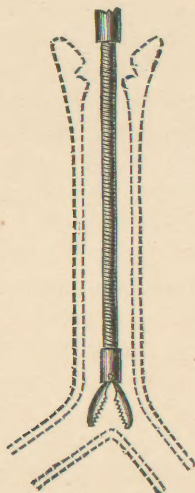
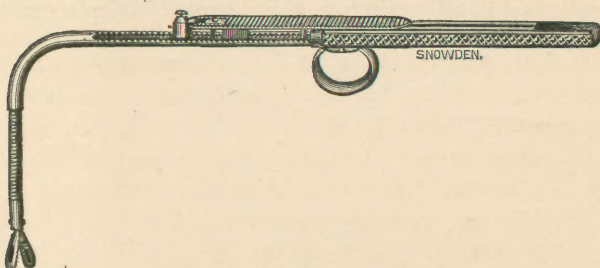
6th. The breadth of the head, the facility with which it can be grasped by the forceps, combined with the lightness of the instrument, make it impossible to force it into the trachea without fracturing the thyreoid cartilage.

As to the forceps, it only differs from ordinary instruments of that class in having a side-hook at each tip to penetrate the ventricular cavities of the speculum and hold

the instrument fast. The tips can be extended so as to render the instrument applicable to all ages and depths of larynges. To engage the speculum in the grasp of the forceps, the tips of the latter are passed into the funnel-shaped cavity and then allowed to open. When the speculum is in the larynx this procedure, prior to extraction, is extremely simple. The forceps acting automatically, their tips have merely to be passed behind the epiglottis and depressed until an obstruction (the bottom of the funnel) prevents further progress. Allowing the forceps to open, they grasp the speculum firmly, when slight traction will suffice to withdraw it. This has been tried repeatedly upon the cadaver. The manipulation of introduction is that recommended by Dr. O'Dwyer for his instrument.

I wish also to show you an instrument devised for the purpose of withdrawing detached membrane from any part of the trachea, from the bifurcation up. It consists, as you can see, of a spiral tube, which, pushed out through the shaft of the body of the instrument, can be lengthened at will from the handle. A small blunt forceps is mounted on the end of the spiral tube, which forceps opens while on the descent and closes as soon as the spiral tube is drawn home. This instrument can be used with the speculum *in situ*, and is so constructed as to not interfere with respiration. For the extraction of foreign bodies from the trachea it will also, I think, render valuable services. I have already had occasion to use it, with gratifying results.

You will pardon me for introducing the laryngeal specula to you before having tried them upon the living subject, the crucial test—the only one, in fact, that can render them worthy of your attention. You will kindly remember that they are merely brought before you to illustrate the ideas set forth in my paper, and that eighteen months will probably elapse before we meet again, and therefore eighteen



months before I have an opportunity of showing them to you. My future plan of procedure with them will be to try them in a number of cases, and when found satisfactory in

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my hands, I will place a number of sets at the disposal of as many general practitioners and request them to study the defects that they may present in *their* hands (naturally not so accustomed to the manipulation of laryngeal instruments as mine), and, these defects once corrected to their and my satisfaction, I shall again have the pleasure of bringing them before you, but in a more mature form.

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